

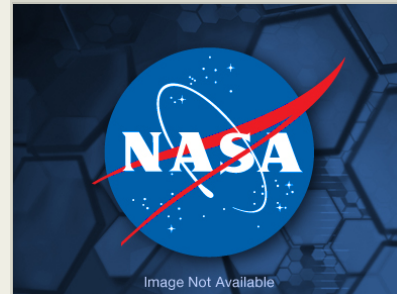
X-ray Line Formation by Charge Exchange

Completed Technology Project (2017 - 2020)



Project Introduction

Existing X-ray telescopes have revealed charge exchange to be a key astrophysical process leading to X-ray emission when highly charged ions from such diverse sources as stellar winds, supernova remnants, or galactic superwinds interact with comets, planetary atmospheres, or the interstellar neutral gas. Charge exchange with bare sulfur ions, for example, was proposed as an alternative explanation of the 3.5 keV X-ray feature in the emission of galactic clusters that had been associated with the possible decay of sterile neutrinos. Fe XVII dominates the spectral emission of a large number of astrophysical X-ray sources and, thus, is of prime diagnostic importance, as illustrated in numerous measurements by Chandra and XMM-Newton. Although immense progress has been made in laboratory measurements and spectral calculations of collisional plasmas since the launch of these X-ray observatories, model calculations of the Fe XVII X-ray spectrum still do not yield agreement with astrophysical observations that is completely satisfactory. As a result, charge exchange has been invoked as an alternative explanation for the poor agreement between models and observations. Theoretically, line formation by charge exchange, however, is still only poorly understood both in the case of the rather 'simple' K-shell spectra of hydrogenlike or heliumlike ions, such as Fe XXV and Fe XXVI, and the more complex L-shell spectra of neonlike ions such as Fe XVII. Experimentally, there is only a small set of laboratory measurements involving X-rays from K-shell ions, and almost no measurements of the charge exchange produced X-ray emission involving L-shell ions. Moreover, the existing laboratory measurements have focused mostly on charge exchange processes pertaining to the solar wind interacting with complex (molecular) gases in cometary and planetary atmospheres. By contrast, we propose here to perform X-ray measurements pertaining to astrophysical exchange processes dominated by atomic hydrogen, molecular hydrogen, and helium. Our measurements will answer the question whether charge exchange can indeed produce the pattern of emission observed near 3.5 keV in the galactic x-ray spectra. It will also identify the signature of line formation by charge exchange in the L-shell X-ray spectra, notably in Fe XVII. Our measurements are very timely not only because of the controversies surrounding current CCD-resolution X-ray observations, but also because of the recent launch of the Hitomi X-ray Observatory. The Soft X-ray Spectrometer (SXS) calorimeter aboard Hitomi will change the way the community will study the X-ray emission from extended sources. For the first time, astronomers have the spectral resolution and the effective area to see individual X-ray lines from diffuse objects. Our proposed measurements will utilize the Livermore electron beam ion trap (EBIT), a newly commissioned atomic hydrogen source, and the EBIT Calorimeter Spectrometer (ECS), which resides at the Livermore EBIT facility and has the same performance specifications as those of Hitomi's SXS. In addition, we will make the first modeling calculations of charge exchange produced X-ray emission of L-shell iron using a model we had developed earlier for studying K-shell X rays. The proposed work will, thus, provide the tools needed to identify and quantify



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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Astrophysics Research and Analysis

Project Management

Program Director:

Michael A Garcia

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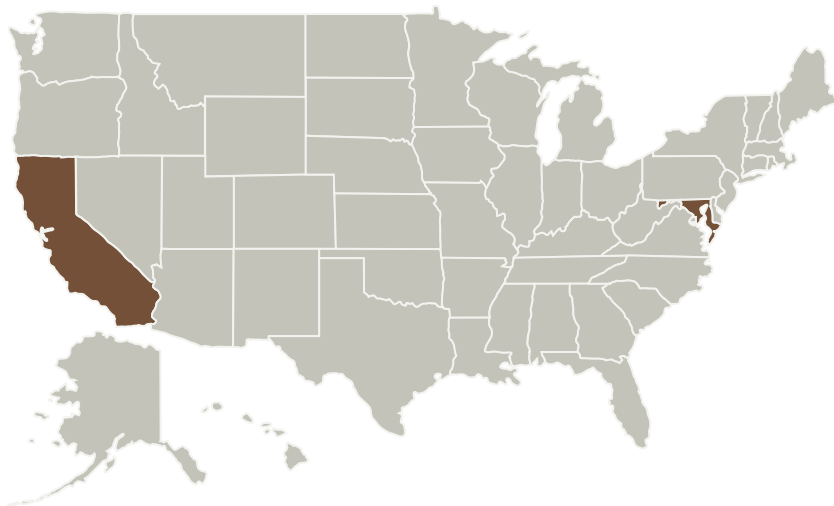
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charge exchange as a line formation mechanism in extended astrophysical objects observed both with current CCD resolution and with the high resolution of the Hitomi X-ray Observatory.

Primary U.S. Work Locations and Key Partners



Primary U.S. Work Locations

California

Maryland

Project Management (cont.)

Program Manager:

Dominic J Benford

Principal Investigator:

Peter Beiersdorfer

Co-Investigators:

Richard L Kelley
Maurice A Leutenegger
Frederick S Porter
Gregory V Brown
Scott W Tyler
Vola M Andrianarijaona
Caroline A Kilbourne

Technology Areas

Primary:

- TX08 Sensors and Instruments
 - └ TX08.3 In-Situ Instruments and Sensors
 - └ TX08.3.1 Field and Particle Detectors

Target Destination

Outside the Solar System